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Computed Tomography for Electron-Beam Welders

A new method for improving the precision and repeatability of welds

Over the past decades, advances in computing power have enabled researchers at LLNL and elsewhere to use computed tomography for nondestructive evaluation of solid objects. An object is x-rayed at tens or hundreds of different angles, and a computer mathematically combines the data to determine density distribution within the object. Computed tomography applied to electron-beam welding uses the same mathematical technique but acquires a different type of data.

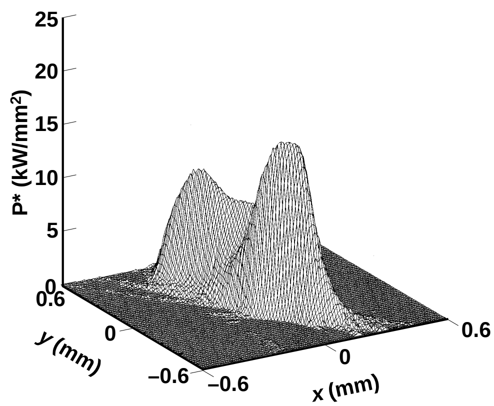
Computer tomography uses a modified Faraday cup (MFC) to acquire profiles of the electron beam at regularly spaced angles around the beam. The beam is swept perpendicularly across a narrow slit in the MFC using the welder's x–y deflection coils, and a digitizing oscilloscope captures the electrical signal coming from the cup. Because the beam is sweeping across the slit, each point in the oscilloscope time record is the integral across a different part of the beam. The known beam sweep speed allows the time record to be converted to a position record, and the result is a profile of the beam. A stepper motor rotates the MFC to the next angular position, and a new profile is taken. A set of data consists of 25 or 50 profiles taken at equal angles from 0 to 180 degrees. These data sets are then processed to reconstruct the power distribution within the beam.

APPLICATIONS

- *Setting up, focusing, and controlling high-intensity electron beams*
- *Detecting and measuring changes over time in an electron--beam welding machine*
- *Ensuring uniformity between different electron-beam welding machines doing similar work*
- *Creating repeatable de-focused beams for surface modification or other special applications*

Improved repeatability and precision

Operators typically focus electron-beam welding machines by placing the beam on a target material and adjusting the focus until the glow seen through the machine's optics reaches an apparent peak in brightness. This subjective method is prone to variations caused by different operators or target materials. Because tomographic imaging examines the beam directly, rather than looking at a secondary effect (the glow), it can be used to focus the beam more precisely and in a manner that can be repeated. Using this technique, the beam can also be tailored for applications that do not require a tightly focused beam, such as surface modification.



Power-density distribution produced by a sharp-focused, hairpin-filament beam.

Developing a portable system

Our next step is to develop a portable system. A portable system will let the operator immediately examine reconstructions of the beam's power distribution and make adjustments to the weld parameters that will generate the desired beam shape. Such a system could be constructed from off-the-shelf components—reserving the major effort for system integration and computer programming.

Availability: The prototype is available now. We invite collaboration with industrial partners to develop a commercially viable system.

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